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THE PHYSICAL GEOGRAPHY OF NEW YORK STATE.

RALPH S. TARR.

PART III.—PLAINS AND PLATEAUX.

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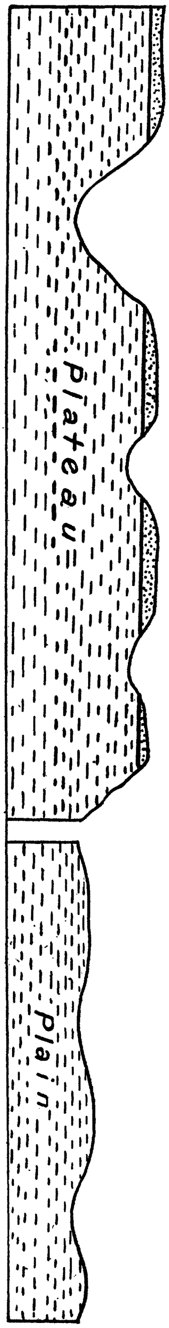

FIG. I.—DIAGRAM TO SHOW THE TYPE CONDITIONS OF PLAIN AND PLATEAU. BASAL LINE SEA LEVEL. CRESTS OF HILLS IN PLATEAU CAPPED BY HARD STRATUM.

DEFINITION.—A plain is a level tract of country, and it is customary to limit the term to level tracts not high above the sea, while those that are elevated are called plateaux. Naturally this distinction has little if any meaning, even in common usage, for there are many so-called plateaux, such as that on the western side of the Appalachians, which are less elevated than the "plains" of the West. Therefore I do not consider it worth while to attempt to maintain the distinction in this article. Plains and plateaux are of the same genus, the difference arising chiefly out of the difference in elevation and the results which this makes possible.

LIFE HISTORY.*—Both plains and plateaux, in their typical development, are notably level areas; but a plain that for any reason begins as a level tract, will, if opportunity offers, become irregular. Upon its surface water will flow; and this, if high enough above sea level, will of necessity cut channels. Hence the plain will begin to be dissected, and if a plateau high above sea level, it may be so deeply carved that, like the Catskills,† it becomes so mountainous that people class it among mountains. Therefore in the development of a plain from an original fairly level condition, greater and greater irregularity is introduced, until the plain becomes a hilly, or, so far as differences in level go, even a mountainous country.

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* Davis, Proc. Am. Assoc. Adv. Sci., 1884, XXXIII., 428–32.

† Tarr, Bull. Am. Geog. Soc., 1897, XXIX., 36.

At first * the streams cut steep-sided valleys, to shallow depths if the plain is low, but as great cañons if on a high plateau. This is because the streams cut rapidly along their channels and carve valleys only slightly wider than themselves. But the weather is at work all the time, and this broadens the valleys, making them less angular. Yet as long as the stream can cut into its bed, *its* action is more marked than that of weathering, and although the valley broadens, it still remains a gorge or cañon. In time, however, the stream cuts so low that further deepening is either greatly checked or wholly stopped. Then the sole action of weathering broadens the valley, and this carving of the plain, in the end, produces broadly sloping valleys and gently rounded hills. This stage is reached much more quickly in a moist than in a dry climate, because the agents of weathering are less active in the latter than in the former. This is one of the reasons why the plateaux of the arid West are crossed by rugged and narrow cañons, while that near the base of the Appalachians is carved into rounded hills and valleys.

Beyond this stage the development is slow; but since the streams can cut no deeper, while weathering is constantly reducing the surface, there is no other end than the ultimate reduction of the surface to a level condition, provided the land stands quietly and nothing occurs

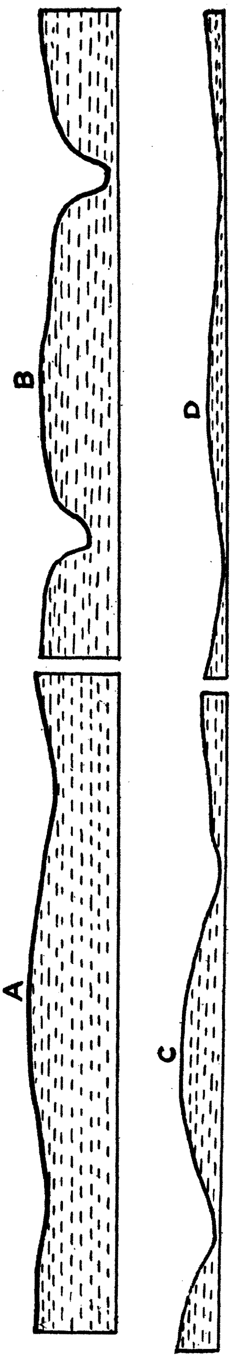

FIG. 2.—TO ILLUSTRATE IDEAL DEVELOPMENT OF PLAIN IN ROCKS OF UNIFORM TEXTURE, STARTING WITH UNDULATING SURFACE IN A; TRENCHED BY STEEP SIDED VALLEYS IN B; THESE BROADENED OUT IN C TO THE CONDITION OF MATURITY; AND FINALLY, IN D, A GENTLY UNDULATING PLAIN DEVELOPED THROUGH DENUDATION, BUT THIS TIME NEAR SEA-LEVEL.

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* Davis, Proc. Am. Assoc. Adv. Sci., 1884, XXXIII., 428–32.

excepting this normal work of water and weather. The plain, at first roughened by these causes, then, after a certain stage is reached, becomes more and more smooth, until in the end it would actually become a plain again, as at the start, though this time with the surface near the sea. It happens that the land *is* in movement, and that other things may occur to interrupt this development, so that the full cycle is rarely, if ever, completed. Of *young plains* (A and B—Fig. 2), that is, those newly formed, there are many; of *mature plains* (C—Fig. 2), that is, those considerably dissected, there are also great numbers; but of *old plains* (D—Fig. 2), those that have passed into a second childhood, we have none of any size that can be proved to be of this origin. The RATE of development from youth to old age, as well as the intensity and variety of surface form produced, will vary greatly with the elevation above the sea, the kind of rock, whether hard or soft, the slope of the surface, etc.

CLASSIFICATION OF PLAINS.*—There are two great classes of plains, those that have resulted from *destruction* of land and those that have been built up, or *constructed.* The former may be called *destructional*, the latter *constructional.* Both classes may be made by several causes, such as the action of the sea, of lakes, of rivers and of glaciers. Plains produced by these causes may be called Marine, Lacustrine, Fluviatile, and Glacial. When a glacier is ending on the land, its melting furnishes both water and sediment in amounts quite different from that which would come under more normal conditions. The action of this ice-furnished water may also build plains, as well as carve them, and these may be called Glacio-fluviatile plains. Volcanic action, by outpouring lava or volcanic ash, may build Volcanic plains. During the general wearing down of the surface, by the action of *denudation*, plains may be formed by the important agents of destruction included in this term. Plains originating from EITHER one of these causes may be newly formed, and hence young, or they may become mature, or, theoretically, any one may have passed to the stage of old age. These facts are graphically stated in the following table, to which are added the names of some of the chief subdivisions of these several classes:

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*See also Davis, Proc. Am. Assoc. Adv. Sci., XXXIII., 1884, 428-32; Powell, Nat. Geog. Monog., Vol. I., 1896, 34.

CLASSIFICATION OF PLAINS.

	CONSTRUCTIONAL.	DESTRUCTIONAL.	
Marine.	Salt marshes. Deltas. Filled bays. Raised sea-bottoms.	Wave cut plains.	Any of these may be young, mature or old.
Lacustrine.	Fresh water marshes. Deltas. Filled lakes. Lake bottom plains.	Wave cut plains.	
Fluviatile.	Floodplains. Terraces.	River cut plains. Terraces.	
Glacial.	Till plains.	Ice-scoured plains.	
Glacio-Fluviatile.	Gravel-filled valleys. Overwash plains. Terraces. Deltas. Sandplains.	Same as Fluviatile.	
Volcanic.	Lava flows. Ash fields.	None.	
Plains of Denudation.	All of the above excepting volcanic.	Plains in horizontal rocks. Peneplains.	

CONSTRUCTIONAL PLAINS.

MARINE PLAINS.—Along a very large part of the sea-coast line of New York, *salt marshes* are in process of construction, and one finds every gradation, from a bay to an extensive marsh. This coast line, which is mostly that of Long Island, is very irregular, and the indentations have chiefly resulted from a recent sinking of the land, which has allowed the water to enter the valleys. Hence the Hudson, and many of the streams of Long Island, enter the sea, not over deltas, but at the head of bays and fjords. These partly protected indentations do not receive the full force of the ocean waves, and hence the sediment that is dragged down from the land by rain-wash and by rivers, is not removed by sea action, but accumulates on the bed of the bays, tending to fill them. An even more important reason for this protected condition over a large part of the coast, particularly along the shores of Long Island, is the construction of bars of sand by wave and wind action. Hence the greater portion of the south shore of this island is largely shut in by sand bars, or beaches, at some distance from the true land margin, or the *old land.* The *new coast* is therefore straighter than the old, and the space between the old and new land is occupied by protected bays and sounds. From here southwards to the Rio Grande, excepting at the southern end of the Florida peninsula and the delta of the Mississippi, these same conditions exist.

Delta Plains.—Where streams enter these bays they deposit their sediment very nearly at the place where the current is checked upon entering the quiet water. The continual dumping of material here will, in time, build ***marine delta plains.*** Layer upon layer is deposited, and the delta grows outward into the bay, with a level upper surface and a steep front under the water, upon the face of which sheets of sediment accumulate at a steep angle (Fig. 4). Thus, built as a plain, which is a part of the sea shore, it cannot grow far above sea-level. Hence, this action makes it a nearly dead-level plain, and when the stream that is building it, and that extends out over it, is in flood, the nearly horizontal channel cannot contain ALL the water that is supplied. Therefore the water overflows the delta and deposits upon its surface a horizontal layer of sediment, so that the plain is actually built a slight distance above sea-level, as is the case in the delta of the Mississippi. Being gen-

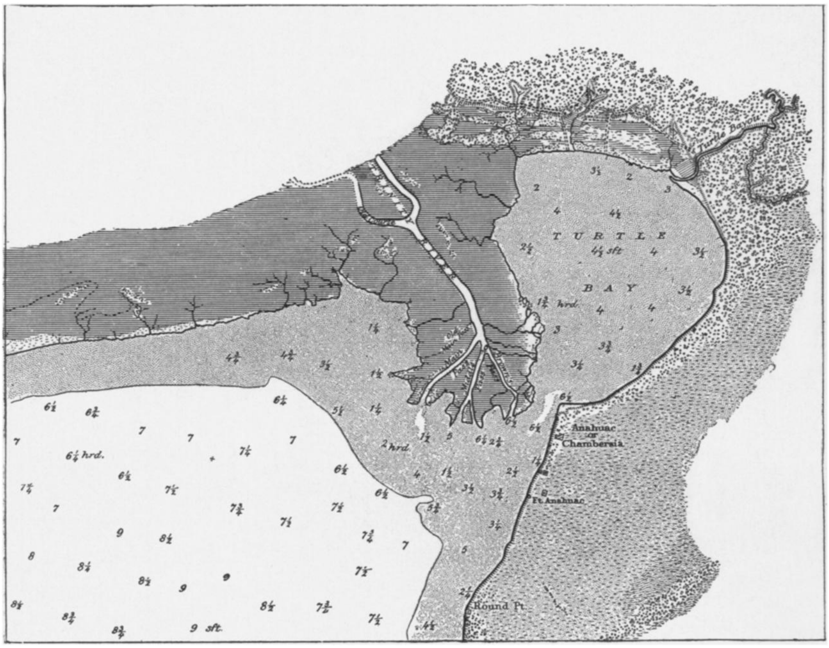

FIG. 3.—MAP OF A DELTA AT THE HEAD OF GALVESTON BAY, TEXAS, WHERE THE TRINITY RIVER ENTERS. NOTE THE SHALLOWNESS OF THE WATER NEAR THE DELTA AND IN TURTLE BAY (FROM U. S. COAST SURVEY CHART 204).

erally enclosed between hill slopes, sediment is washed from the sides; and hence, under such conditions, the delta is a plain sloping from the valley-sides toward the middle, and from its head to its margin, which is really some distance under water, where it terminates in a terrace front that is constantly being extended seaward.

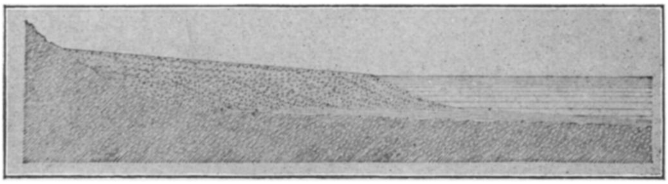

FIG. 4.—IDEAL SECTION OF A DELTA, AFTER GILBERT. SEA-LEVEL THE HORIZONTAL LINE ON RIGHT.

Such a delta plain is very level, but yet is marked by some depressions and elevations. Places, especially those near the stream channel, where more deposit is made, rise above this level, and the river may enter the sea through two or more mouths, or *distributaries* (Fig. 3). Now and then it abandons one of these, or changes its course, thus leaving the old channel and carving a new one. Then the abandoned channel becomes a *bayou*, and later, cut off from the sea and river by the deposit of sediment, may become a lake. But these are all minor irregularities in a plain of remarkably uniform general level.

Filled Bays.—The sediment brought by the rain and the small streams, as well as that coming from the large rivers, together with some of wave origin, drifted about by tidal currents, is strewn over the bed of the bay. This is deposited quite irregularly, according to the rate of supply and the velocity of the current, which varies from place to place. If this filling continues long enough, the effect would be to transform the bay to a level plain (a *filled bay*), whose elevation was approximately that of the sea-level, at which level further deposit would be greatly checked and finally stopped.

Salt Marsh Plains.—This work of bay-filling is greatly aided by the action of marine plants.* When any portion has risen nearly to the low-tide mark, eel grass commences to grow, and this, by checking the velocity of the tidal current, adds to the shallowness, which is still further increased by the death of the eel grass itself, as well as by that of the animals which it supports. This continues about to the low-tide level, where the eel grass ceases to be able to thrive. Above this there is a barren zone up to the level of the midtide, where other plants, the salt marsh grasses, commence to thrive, with the same result. They can grow upon a salt swamp up to the level of the highest tide, and as a result, by their aid, extensive plains are being built in the enclosed bays; and in some places these stretch as salt marshes from the ocean beach or bar to the margin of the old land (Fig. 6). They are remarkably level marine swamps, with minor irregularities, which are covered at very high tide, but exposed to the air for most of the time. Through them extend many river-like, tidal channels, through which the rising and falling tide passes. In time even these are filled, and gradually the plain is raised above the level of the highest water, and the salt marsh then becomes dry land.

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* Shaler, Sixth Ann. Rept. U. S. Geol. Survey, 1885, pp. 353–398.

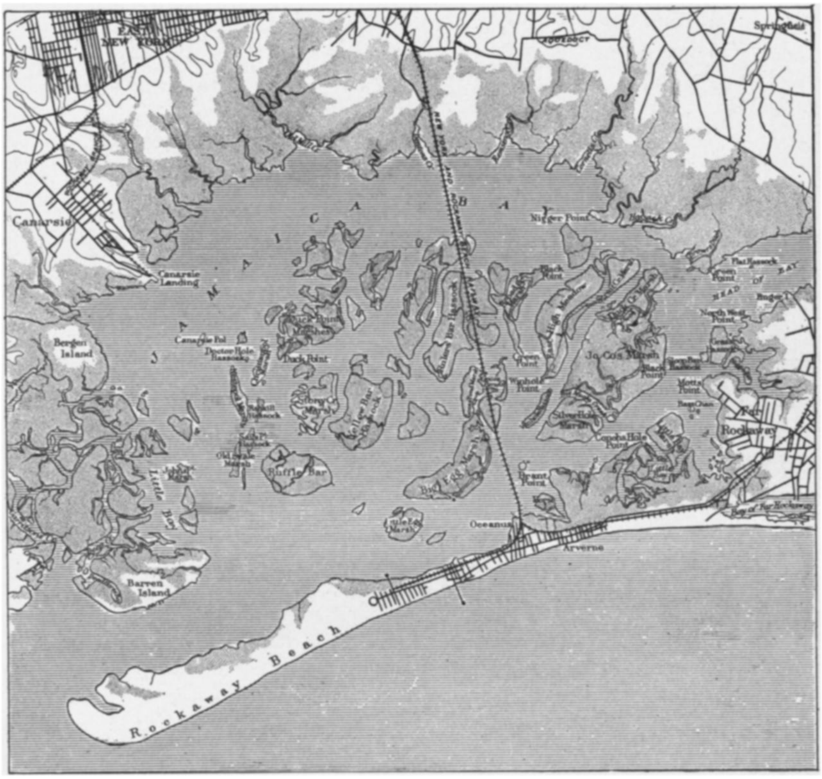

FIG. 5.—A NEARLY FILLED BAY JUST SOUTH OF BROOKLYN ALMOST ENCLOSED BEHIND A BAR CALLED ROCKAWAY BEACH. VERY NOTABLE DEVELOPMENT OF SALT MARSH, REPRESENTED BY THE DOTTED SHADING (FROM BROOKLYN SHEET, U. S. GEOL. SURVEY).

These salt marsh plains have considerable economic importance. There are scores of thousands of acres along the sea coast, not far from the large cities, which need only the exclusion of the tide to transform them to arable land. Already this has in some cases been done by artificial diking, and in the Evangeline County of Nova Scotia, near Cape Blomidon on the Bay of Fundy, on the coast of England, and particularly in Holland,* very extensive salt marsh plains have been reclaimed from the sea. In time, however, nature herself will reclaim them.

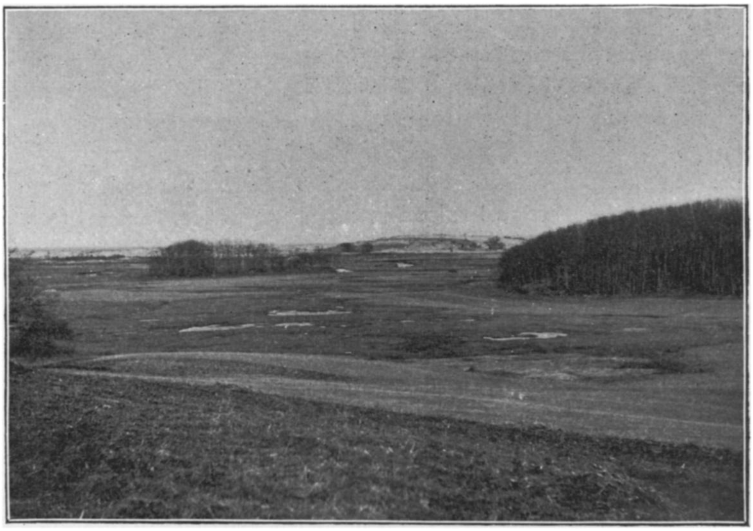

FIG. 6.—SALT MARSH PLAIN AT IPSWICH, MASS. WOODED GLACIAL HILLS RISE ABOVE THE PLAIN, AND THE OCEAN SAND BAR, BEHIND WHICH IT HAS BEEN FORMED, IS SEEN IN THE WHITE HILLS IN THE BACKGROUND (PHOTOGRAPH BY J. L. GARDNER, 2d).

Not far from the City of Brooklyn, and along the coast of New Jersey, just south of New York City, there are extensive salt marshes, † and all along the Long Island shore, as well as that of Connecticut to the north of this, there are patches of this marshy land. ‡ Sometimes these grade almost imperceptibly into dry land; and habitable plains end, without any sharp line of demarkation, in a salt marsh. Being nearly at sea-level, the marine plains so far described, unless elevated, can pass through no complex stages of development, but will remain level tracts of land near sea-level, and crossed by streams flowing in almost imperceptible valleys.

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* Smock, Ann. Rept. New Jersey Geol. Survey, 1892; 313–353.

† Vermeule, Ann. Rept. New Jersey Geol. Survey, 1896; 287–317.

Cook, Geol. Survey, New Jersey. Report on Cape May County, 1857, pp. 15–65, 91–94; Ann. Rept., 1869, pp. 23–41; Geology of New Jersey, 1868, pp. 300–308; Annual Report, 1885, pp. 61–70.

‡ Mather, Geol. of New York, First Dist., 1843, pp. 17–19; p. 234.

Raised Sea Bottoms.—Further to sea, beyond the new land, the tidal currents and waves are distributing sediment over the bottom, building a plain on the ocean bed. For a distance of 75 or 100 miles from the New York and New England coasts there is such a plain of remarkable levelness, made of layers of sediment which have obscured many of the irregularities that may have once existed. If the land along this part of the continent should rise to an elevation 600 feet above the present, there would be a coastal plain sloping gradually from the present shore line to the new sea shore. Such an elevated *sea bottom plain* would be a constructional plain built by deposit and raised into the air by the forces of elevation.

This case finds no actual present illustration within this State; but just south of it, in New Jersey, and from there to the Rio Grande, the lowlands bordering the coast are actually of this origin. The plain of the Pine Lands of New Jersey (Fig. 7) and the coastal plains* of the Southern and Gulf States, represent an old sea bottom slightly elevated above the ocean. That of Texas has been so recently elevated that fossils of animals now living in the Gulf are enclosed in the clays; and it is so young, and the slope so moderate, that it is a great, swampy tract, with streams flowing almost without valleys.

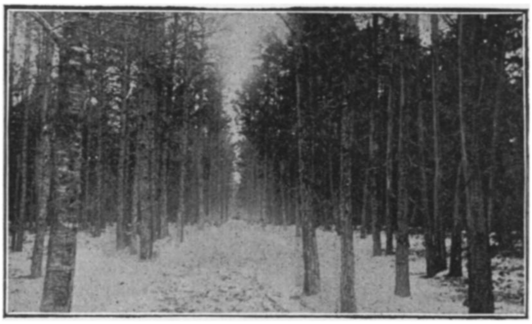

FIG. 7.—IN THE PINE-LANDS OF NEW JERSEY. RAISED SEA-BOTTOM PLAIN (DAVIS SERIES OF GEOGRAPHICAL LANTERN SLIDES).

While at present New York has no such plains as these, we are able to look back in time to a period when there were such level tracts stretching westward from the old land which existed among the ancient Adirondacks and New England mountains (see Part II of this series). Near the close of the Paleozoic, when the Appalachians were uplifted, these *coastal plains* were elevated above the great interior sea, and they were very extensive, including the greater part of New York. It was upon this plain that the vegetation grew out of which the coal beds of Pennsylvania have been made; and it is not improbable that similar tree-covered swamps at the same time existed in New York, although now all traces have been removed by denudation. The history of this ancient plain, since that time of first uplift, has been so complex, and the record of it so battered by the attacks of the agents of destruction, that it is only by a careful study of the geology of the region that we are able to state these facts. The low plains have been raised to plateaux and greatly dissected and transformed (Fig. 17); but in the beginning they were true sea-bottom plains.

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* McGee, Twelfth Ann. Rept., U. S. Geol. Survey, 1891, pp. 347–521.

LACUSTRINE PLAINS.—*Lake-Bottom Plains.*—In lakes very nearly the same kinds of plains are made as those of the sea, and this State furnishes many illustrations of the several kinds. During the closing stages of the glacial period there was an ice dam across many of the streams; and temporary lakes existed where now there is dry land.* Most of these were small, and the deposits in them have built either small plains, or else have not been extensive enough to smooth over the lake bed. Such plains may be looked for in many of the valleys of the north-flowing streams, most of which were held back by the ice dam. However, in the case of the Great Lakes,† while the outlet through the St. Lawrence was clogged by ice, the level of the waters was raised so that at one time the outflow was past Chicago, and at another past Fort Wayne, Ind., and still later through the Mohawk in New York. The last stage existed for a long time and extensive beaches were built. Beaches made during these high-water levels were constructed along the shores of both Erie and Ontario. These extend as ridges or narrow plains, which are really terraces, remarkably level and continuous.

During this stand of the water, deltas were constructed which now exist as broad, level-topped areas of gravel. Over the bed of the lake, sand and clay were strewn, filling some of the depressions, so that the surface, already quite level, was made into a more typical plain. Therefore, south of the beach-terraces and ridges now forming on the present lake shore, there are plains which were once lake bottom, and which owe some of their levelness to this fact.

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* For the Red River plains of Dakota and Canada, see Thomas, Hayden Geol. Survey, Sixth Report, 1872, p. 293; Upham, Monograph, U. S. Geol. Survey, Vol. XXV., 1895. For Bonneville Plain, see Gilbert, Monog., U. S. Geol. Survey, Vol. I., 1890. This lake bottom plain is not of glacial origin.

† The history of the Great Lakes will form a separate part of this series, and then these deposits will be more fully described with bibliographic references.

If Lake Erie should be drained there would be a similar, though much more extensive, plain on the site of the lake.

*Lake Delta Plains.**—In lakes, especially the smaller ones, the water is shallow, the bottom is not sinking, and there is only slight wave action, and no marked tides. Hence in these there is less chance of removal of sediment than in the sea. Rivers bringing their load to the ocean do not succeed in accumulating all of it near their mouths, but much of it is strewn over the sea floor, being carried hither and thither; those entering lakes lose nearly all of their load, and most of it is dropped near their point of entrance. The lake filters the water of its sediment, so that the outflowing stream is pure and clear. Some of this sediment is strewn over the lake bed; but most, and the heaviest, settles near the river mouth, building a delta. Therefore opposite the mouths of most streams entering lakes there are true delta plains, some of which are quite extensive.

In the Finger Lakes these are abundant, and at the head of each of these there is a broad flat which is a true delta. These are not truly level, but extend beneath the lake water at their margin, are swampy near the shore, and rise gradually both from the lake shore and from the central part of the valley toward the margin. This elevation of the surface is due to the deposit of sediment brought by the normal river floods. The town of Ithaca, at the head of Lake Cayuga, is built on such a delta, and mainly on the eastern side of it. The town of Watkins, at the head of Lake Seneca, is on the western side of a similar delta. The position of these towns is due to the fact that the tributary streams from the east are more numerous in the former case, and from the west in the latter. They have elevated the surface of the delta near their mouths, and transformed it to dry land, while the opposite side is swampy. These are true, though very flat, alluvial fans.

Lake Swamp Plains.—As in the case of the sea, so in lakes, when the bed has been raised enough, vegetation commences to take root. On the exposed shores of large lakes this is not possible, because the waves keep the mud and sand in such movement that the plants cannot take root; but here, as in the sea, there are bays, and there are also places protected by sand bars, and in these vegetation can grow, as it can also in the smaller lakes in which large waves cannot be generated. The life and death of plants helps to build up the bed, partly by their own addition, partly by the accumulation of remains of animals which thrive in the plant-covered plains, and partly by entangling sediment, and causing it to settle in the quiet water. These often transform the shores of lakes, especially small ones, to swampy plains.

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* Gilbert, Monograph, U. S. Geol. Survey, Vol. I., 1890, pp. 65–70; 153–167.

Filled Lake Plains.—In the end the work above described may completely *replace* the lake by swamp. A very large majority of the peat-bog swamps of New York, such as those which abound in the Adirondacks,* are the result of this transformation of lake to swampy plain by the filling of the lake, at first by the deposit of sediment, and later by the aid of plants. Many of these bogs have been cut into for one purpose or another, and in them one commonly finds, after passing through several feet of peat, perhaps with thin layers of marl, a bed of clay which represents the first step in filling the old lake or pond. There are thousands of acres of such plains in New York, and some of them are of large size. In Nova Scotia one may frequently see such plains with a diameter of two or three miles.

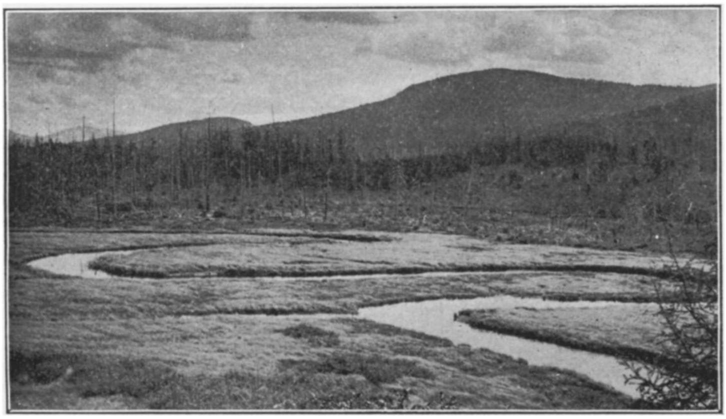

FIG. 8.—STREAM (RAY BROOK) IN THE ADIRONDACKS MEANDERING THROUGH A FILLED LAKE PLAIN (PHOTOGRAPH BY S. R. STODDARD, GLEN'S FALLS, N. Y.).

FLUVIATILE PLAINS.—If, for any reason, a stream flows over a level area with such moderate slope that in time of flood all the water cannot be carried in the channel, when it overflows its banks it spreads out as a sheet of water on either side of the channel. In this lake-like expanse the current is so reduced that some of the sediment is deposited as a sheet, by means of which the irregularities are smoothed over, and a plain formed. This flood-plain is gradually *built* up, and in time may become very extensive, as in the case of some of the great rivers of the world, like the Mississippi.

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* Smyth, Am. Geol., 1893, XI., 85–90.

New York has no such great FLOODPLAINS, though many streams are bordered in part of their course by small ones. This is true, for instance, of streams flowing over deltas, or where they pass across swampy plains that have been built up by lake filling. They also exist where the river course is interrupted by deposits of glacial drift. In parts of the Hudson there are extensive, though narrow floodplains; and in the Susquehanna, Mohawk and Alleghany valleys there are level areas which are true floodplains, and over which the river rises when in high water; but though these are at times of considerable area, they are nowhere of great extent.

These bordering plains may become true *terraces*,—that is, narrow plains bordered toward the river by a steeply descending bank; and often, on the side away from it, by a steeply ascending slope. These are generally due to the cutting action of the river (p. 49), but such terraces are occasionally *built up* by river floods of variable height.* Since none are known in New York it will be sufficient merely to mention this class.

GLACIAL PLAINS.—By these are meant plains constructed by the direct action of the ice itself. When the continental glacier extended across New York, covering the entire area of the State, which was, therefore, transformed into a plain or plateau by the ice covering, all irregularities were submerged and there was a great *ice plateau*, like that now covering Greenland. While this ice existed, moving slowly southwards, it ground the surface somewhat, picked up a load of rock fragments, and dragged these southwards. When these reached the end of the ice, part went away in the streams furnished at the glacier's end by the melting ice, and part accumulated along the margin, forming terminal moraines. There was a constant procession of rock fragments toward this margin, and at any one time the ice held considerable in its grasp, firmly frozen in the bottom layers of the glacier, as we find at present in Greenland. When the ice melted, this *débris*, *till* or *boulder clay* it is called (Fig. 9), was left at the place where it happened to be, so that much of the surface of New York is now covered with a coating of boulder clay, in which clay is the chief element, but scattered through which are numerous boulders of rock not found in any of the neighboring ledges, but dragged from the north; and upon their surface are often seen scratches which they have received on the journey. This till layer varies in thickness, sometimes barely covering the rock, or even being entirely absent, sometimes reaching a thickness of several hundred feet. In the Western States the general till covering is very deep, so thick, in fact, that the preglacial topography has been almost obscured beneath a great thickness of drift. Borings for oil and gas in Ohio and Indiana have revealed buried river valleys beneath the thick till covering of the prairies. Therefore, this part of the extensive plains of the Central States owes its levelness, in large part, to the glacial deposits, and is, therefore, a true till plain.

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* See Tarr, Am. Journ. Sci., XLIV., 1892, 59–61.

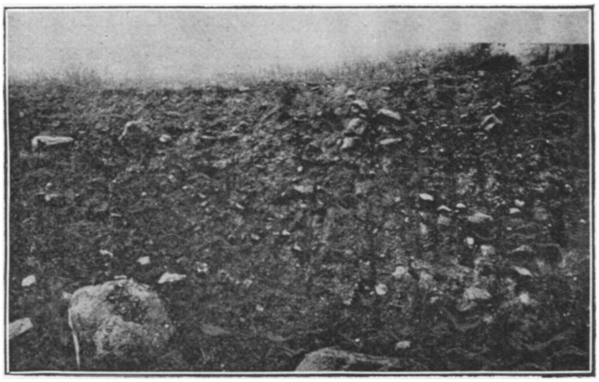

FIG. 9.—SECTION IN TILL OR BOULDER CLAY IN PENNSYLVANIA (LEWIS, REPT. Z, PENN. GEOL. SURVEY).

Most of New York is too hilly for this, but the glacier has greatly reduced the original irregularities, partly by cutting down the hilltops, and partly by carrying off the materials thus derived and depositing them in the valleys. There are hundreds of cases in which stream valleys have been so filled, that, after the ice left, the rivers were not able to occupy them. Some of these are still to be seen as sags in the surface, but others are entirely obscured, though the great majority have merely had their depth decreased by the deposit of drift. By this means the valley bottoms, originally one or two hundred feet deeper than at present, have been filled with till and transformed to valley-bottom plains.

In addition to this, there are narrow, terrace-like till plains, clinging to the hillsides above the valley bottom, apparently representing deposits held *under*, or in the bottom of the ice, when the valleys were filled by the glacier, and allowed to drop down into their present position when the ice support was removed. In the hilly plateau region, near the divide of the Finger Lakes and Susquehanna, there are many terraces of this origin.

Besides these small plains, there is one extensive level area which owes at least a part of its levelness to this cause of ice filling. This is the plain which borders the Lake Ontario shore (p. 52), and which, except where roughened by irregular glacial deposits, is, in general, remarkably level. The surface of this must have been *somewhat* level before the ice came; but presumably it was crossed by river valleys. Indeed, some of these still show, as in the case of Irondiquoit Bay, which is apparently the pre-glacial course of the Genesee River. Practically all, however, have been obscured by the glacial deposits; and so this, which was apparently a dissected preglacial plain, is now a very regular till-covered plain.

GLACIO-FLUVIATILE PLAINS.—While the ice front stood at its farthest limit it reached into Pennsylvania, then covering nearly the entire area of New York; but as the glacial period waned, the ice melted, and its front gradually stood along lines farther and farther north. Wherever it remained its melting furnished the streams with great volumes of water and of sediment, thus introducing conditions quite different from those of the present and the earlier past. It may be said that this water and sediment, escaping from the ice front, passed either into streams leading *away from* the ice, or into streams flowing northward which led *toward* the ice front. In the former the water found ready escape; but in the latter it was ponded by the ice dam. In both cases the great volume of sediment-laden water built deposits of interest, some of which are true plains, though usually not of large size.

*Gravel-Filled Valley Plains.**—Where the water found a slope down toward the south, either this was sufficient to allow the great floods to carry all of the sediment, or else it was too slight for this; and in the latter case some of the load had to be deposited. Because so much sediment was supplied, the latter was frequently the case. Even at present, at the margins of the Alpine glaciers, the streams are not able to carry all their sediment load down the steep mountain valleys; and a similar condition is found along the margin of many other glaciers, notably the Malaspina of Alaska (Fig. 10). Hence the streams, depositing some of their sediment, gradually built up their beds, perhaps flowing over the plain in numerous *anastomosing* channels. By this means many valleys of streams flowing southwards from the glacier have had a deep filling of sand and gravel.* One may see this class of plain in many of the tributaries of the Susquehanna and Allegany. They are so numerous that some form of development of them may be looked for in nearly all of the south flowing streams of New York.

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* Salisbury, Ann. Rept. New Jersey Geol. Survey, 1892, pp. 96–125.

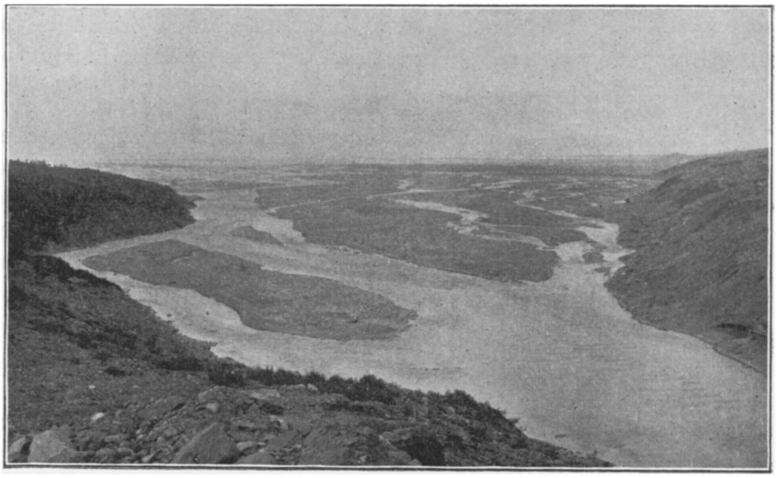

FIG. 10.—DELTA PLAIN BEING FORMED AT MARGIN OF MALASPINA GLACIER BY DEPOSIT OF GRAVELS BROUGHT BY THE WATER FROM THE GLACIER, BUT NOT CAPABLE OF BEING CARRIED FARTHER (PHOTOGRAPH BY PROF. I. C. RUSSELL).

The influence of this kind of deposit is felt even as far as the sea. The floodplain and delta of the Mississippi contain a vast amount of sediment furnished by the melting glacier, and some of the loess of the Mississippi Valley, by which certain prairie areas have been made, had a similar origin. The building of these gravel-filled valley plains, and the prairie areas of fine grained clay, was aided by the fact that when the ice was melting away from the country, the land was lower in the north than now; and hence the south-flowing streams had their grade decreased.

Overwash Plains.—Where the surface was moderately regular, but gradually sloping toward the south, many small streams escaping from the ice front combined to build coalescing plains, or flat, alluvial fan deposits, to which the names *overwash plains* or *frontal aprons* have been given. Within the boundary of New York these are typically illustrated on the south side of Long Island,† where there are extensive sandy plains bordering the southern margin of the terminal moraine. In the more hilly region of central and western New York there was little chance for these to be formed. Their place is taken by gravel-filled valley plains, though here and there these are broad enough to be classed as frontal aprons. An illustration of this is found just southwest of Cortland, N. Y., and another at Elmira and Horseheads.

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* Brigham, Bull. Geol. Soc. Am., VIII, 1897, 17–30.

† Lewis, Am. Journ. Sci., XIII, 1877, 235; Upham, Am. Journ. Sci., XVIII, 1879, 81–92, 197–209; Hollick, Trans., New York Acad. Sci., 1894, XIII, 123–130.

*Terrace Plains.**—In many of the stream valleys flowing southwards there are well developed terraces, which are true plains, narrow to be sure, and extending parallel to the streams, sloping southward with them. Nowhere are they better developed than in the Connecticut River valley, where, in some places, there is a series of several well developed terraces, composed of clay, sand and gravel, with level top and steep margin. In origin they are associated with the withdrawal of the ice sheet; but there are two possible explanations, one of which only (constructional) is mentioned at this point. (For the other see p. 49.) This explanation is that the sediment-laden river water was subjected to risings and shrinkings with the change of season. In winter the river was small and occupied a narrow channel. In spring it rose to a higher level and had a broader channel, the present first terrace top; in summer, rising still higher, it filled a still broader and deeper channel, etc. By this explanation each level of the floods occupied a channel of different breadth and depth; and, since *deposits* were being made all of the time, terraces were built, just as a *single* terrace is being made by rivers which occupy a narrow channel at ordinary stages, and a broader one during flood times, when they overflow their floodplains. The floodplain is a true terrace of construction, and accordingly, if this explanation is true, such terraces as those of the Connecticut are merely the floodplains made by floods which rose to different levels in different seasons.

Deltas.—Where the glacial streams entered valleys whose natural slope was toward the north, they were transformed into lakes in which their sediment was deposited, as it is in any lake; and since many of these have now entirely disappeared, the deposits that were then made, now appear as part of the land surface. Some of these have made plains like those existing around the shores of the Great Lakes (p. 37). Generally the *beach terraces* are indistinct, though they are very prominent along the ancient shores of Ontario and Erie, and less so about some of the smaller, entirely extinct lakes. Therefore, in many places, as, for instance, along the margin of the

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* Tarr, Am. Journ. Sci., XLIV, 1892, pp. 59–61.

Finger Lakes * and Lake Chautauqua, there are gravel terraces, quite level-topped, which border the tributary streams at various elevations above the present lake surface. These streams, flowing down the hillside, entered the lakes during their higher stages, deposited their sediment and built deltas (Fig. 11), as streams are now doing where they enter these lakes at lower levels. They, therefore, stand as witnesses of the former higher water levels.

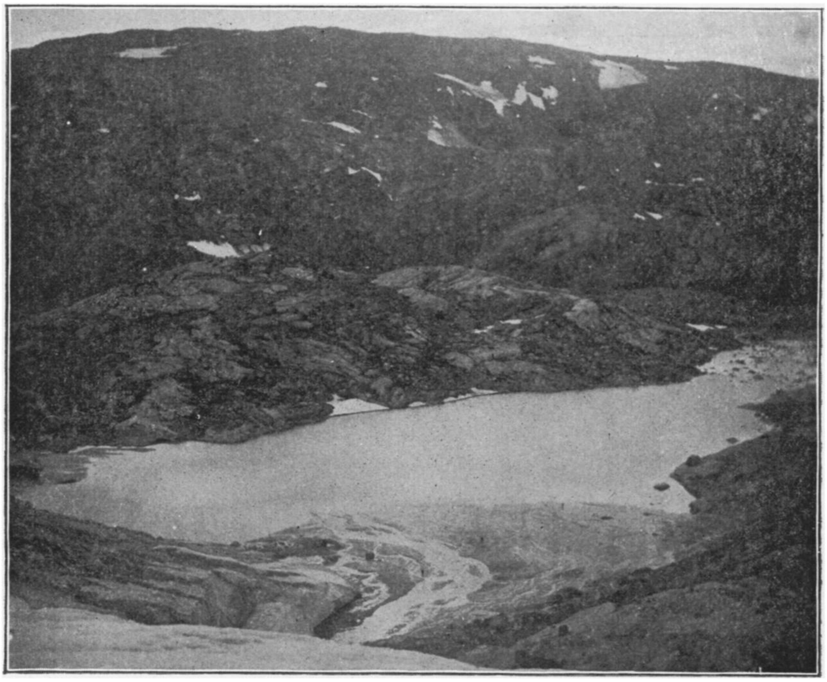

FIG. 11.—SMALL DELTA BEING MADE IN A LAKE AT THE MARGIN OF THE GREENLAND ICE SHEET AND SUPPLIED WITH WATER FROM THIS GLACIER.

Sand Plains. †—Even more extensive plains of gravel exist here and there in these valleys in positions where it is difficult to account for the source of the gravel. These *sand plains* have the form of true deltas with level tops, furrowed with numerous channels and terminating in a steep front, facing southwards. They were evidently built by the deposits made from a gravel-laden stream, now extinct; and careful studies have shown that these streams came from the ice which was forming the dam for lakes now gone, as are the streams themselves. Such plains have not been described from New York, but one is found north of Geneva and another, possibly of this origin, near the town of Brookton, just southeast of Ithaca.

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* Hall, Geology of New York, 4th Dist., 1843, pp. 342–7; Lincoln, Am. Journ. Sci. XLIV, 1892, 297; New York State Museum Report, Vol. 48, 1895, p. 74; Fairchild, Bull. Geol. Soc. Am., VII, 1896, 423–452.

† Davis, Bull. Geol. Soc. Am., Vol. I, 1890, p. 195; Gulliver, Journ. Geol., Vol. I., 1893, p. 803; Upham, Bull. Geol. Soc. Am., Vol. VIII, 1897, p. 183.

OTHER PLAINS.—During the stay of the ice upon the land, the elevation with reference to the sea-level was lower than now, and the sea entered the Hudson River at a higher level than at present. Then the streams tributary to this river entered a fjord; and being loaded with sediment,* they built deltas and terrace deposits in the Hudson itself and its tributaries. Many of these furnish illustrations of these plains, as may be seen near the mouth of the Mohawk and Catskill.†

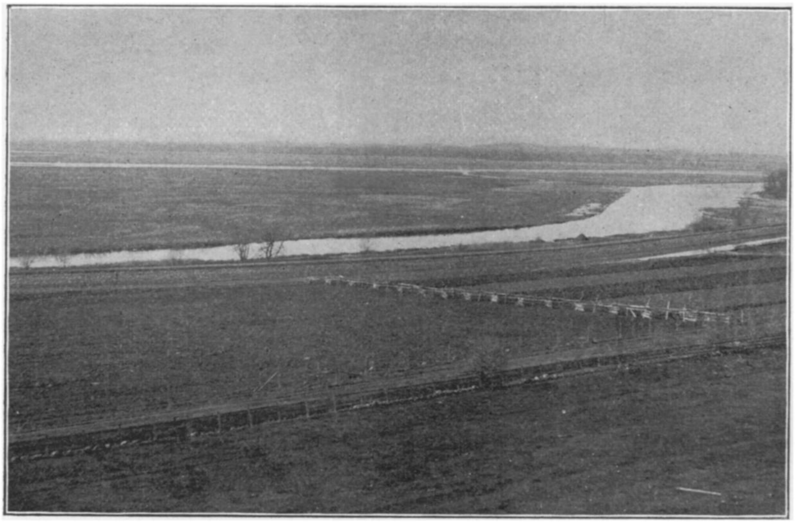

FIG. 12.—THE MONTEZUMA MARSHES, NORTHERN END OF CAYUGA LAKE (PHOTOGRAPH BY C. S. DOWNES).

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* Streams then carried more sediment than now, both because the ice was furnishing them with it, and because the land from which the ice had recently disappeared had not yet been protected by vegetation, so that the rain fell upon it with something like the effect that is produced when it falls upon a road, or a ploughed field, in contrast to a pasture or a forest.

† Hale, Am. Journ. Sci., 1821, III, 72–3; Finch, same, 1826, X, 227–229; Mather, Geol. of New York, 1st District, 1843, pp. 129–158; Dwight, Trans. Vassar Bros. Inst., III, 1884–5, 86–97; Davis, Proc. Bost. Soc. Nat. Hist., XXV, 1892, pp. 318–335; Ries, Trans. N. Y. Acad. Sci., 1891, XI, 33; Merrill, Am. Journ. Sci. 1891, XLI, 460–66; Taylor, Am. Geol., 1892, IX, pp. 344.

In the temporary lakes not only was sediment deposited in abundance opposite stream mouths, but some was carried out into the lake and strewn over the floor,* which in some cases was transformed to a plain of gravel, sand or clay (p. 37). Some of these plains are now to be seen in the north-sloping valleys, in which they resemble the gravel-filled valleys of south-flowing streams. In other cases, as in the Montezuma marshes (Fig. 12) at the head of Lake Cayuga, and the Conewango Swamps southeast of Jamestown, in Chautauqua County, there are extensive lake-bottom plains, still in a swampy condition.

VOLCANIC PLAINS.—Since New York is not a volcanic region, there are no illustrations of these plains within its boundaries, and therefore this subject may be quickly passed over. A lava flow, spreading out over a moderate slope, fills irregularities and may build a plain; and so also may volcanic ash erupted and strewn over the country on one side of the cone. Lava plains have certainly existed in the Connecticut Valley, and possibly also in New Jersey; but subsequent changes have entirely destroyed the plains, for the lavas now stand tilted into mountainous elevations.† In the far West many of the plateaux are capped by lava flows of this origin.

DESTRUCTIONAL PLAINS.

WAVE-CUT PLAINS.‡—The agents of denudation are planing down the surface of the land and carrying materials toward the sea, where extensive plains are being constructed (p. 31); and on their way, stopping in lake or river valley, plains of small extent may be *built;* but in the course of this work of degradation, plains may also be formed by the very *work of destruction*, without the action of building. For instance, the waves, either of lake or sea, may saw into the land, forming wave-cut plains which are generally of small extent and lie beneath the water. Later, these may, perhaps, be raised above the surface.

This horizontal planing of the land by ocean waves is believed by many to have produced grand results in the past, and this has been especially urged by the British geologists. Standing upon the tops of the hills in the Highlands of Scotland and England it is found that they rise to nearly the same level, and it has been suggested that these hilltops are remnants of an ancient *plain of marine denudation*, formed at a time when these islands were at a lower level, during which the waves beat against them for such a long time that the lands were bevelled. Elevation has since raised these plains and streams have cut into them, so that only remnants now remain in the form of hilltops reaching to a nearly uniform level. Since the rocks of the region are of different degrees of hardness, the explanation of the uniform hilltop level must be some condition of lower level than the present; and one possible explanation is this which has been stated. American geologists are inclined to call these remnants *peneplains*, which have resulted from denudation in the air (p. 55).

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* Ries, Trans. N. Y. Acad. Sci., 1893, XII, 107–109.

† See second article of this series, Bull. Am. Geog. Soc., XXIX., 1897, 34.

‡ Gilbert Monograph, U. S. Geol. Survey, Vol. 1, 1890, pp. 35–36.

RIVER-CUT PLAINS.—As they are cutting their valleys, rivers are caused to meander, and the curve of meander changes gradually, so that in the course of time the river shifts its bed, having its channel now on one side of the valley and now on the other. As it swings it cuts a plain whose width is equal to the change in position. This is known as *planation.**

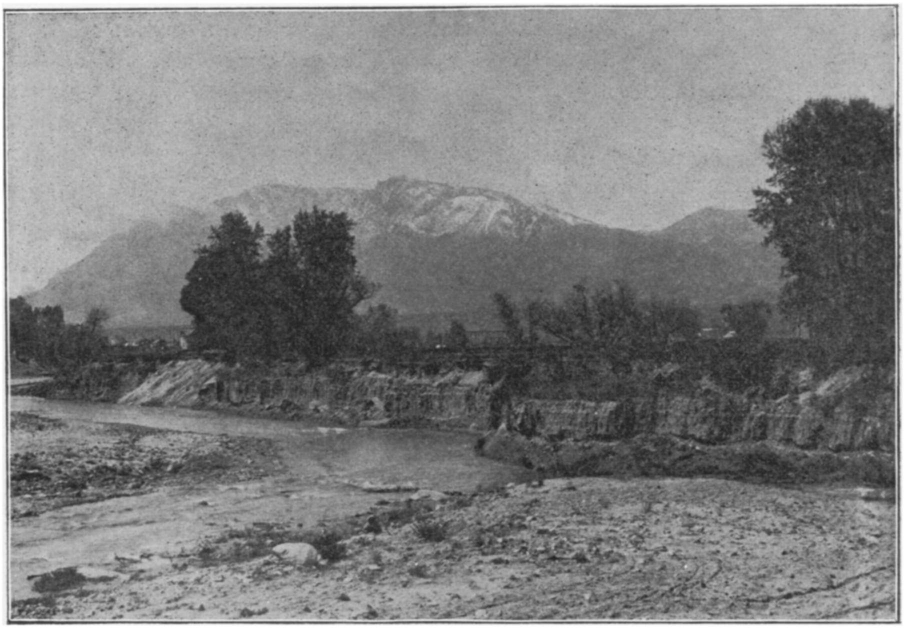

FIG. 13.—TO ILLUSTRATE TERRACE FORMATION BY LATERAL CUTTING OF A RIVER, WHICH IS ALSO CUTTING INTO ITS BED. THERE IS HERE ONE TERRACE; BUT IF THE STREAM CHANGES ITS POSITION TO THE LEFT, AND THEN CUTS DOWN ALONG ITS BED, A LOWER TERRACE WILL EXIST WHERE THE RIVER BED IS NOW LOCATED (PHOTOGRAPH BY JACKSON, DENVER).

It is by this action that it is believed that the terraces of destructive origin are formed. According to this theory, as applied, for instance, to such a river as the Connecticut (p. 44), floods of glacial waters, instead of *building* terraces, gradually *deposit* the sediment in a sheet over the river bottom, building up an extensive gravel plain like those described above (pp. 42–43). After the sediment supply ceased, the stream began to cut a valley in this, for it was no longer *overburdened* with sediment, and its slope was increased by the uplift of the land in the north. Cutting a channel in one place, and then gradually swinging laterally to another point, where it remained to cut another channel, and then changed again, etc., the gravel plain was carved into a series of terraces as the river excavated its channel in the gravel.* Both the constructional and destructional theories apply to these gravel terraces; and since sometimes one and sometimes the other of these causes account for them, a study must be made of each case in order to tell which is the real explanation.

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* Gilbert, Geology of the Henry Mts., Washington, 1880, p. 120.

The destructional cause for terraces is the more common, and there are many terraces of this origin in New York, where the rivers have excavated their valleys in the till deposits. As has been stated, many of the mature valleys of New York have been partly clogged with a till filling (p. 41); and since the ice left the streams have been busy carving new valleys, and in the course of their work they have cut terraces. The majority of small streams, as well as some of the larger ones, have such bordering plains extending parallel to them, and descending at the same rate. They can be told from others by the fact that they are made in the boulder clay, which is quite different from the stratified gravel of the gravel-filled valleys.

ICE-SCOURED PLAINS.—This is merely mentioned in order to fill out the classification, though no plain of this nature is known to exist in the State. In passing over the surface of a moderately regular land, the glacier will plane down the hills, leaving the surface more regular as a result of the scouring; and in the course of time, perhaps, the region will be reduced to the condition of a plain by actual ice carving.

PLAINS OF DENUDATION.—Where rocks are nearly horizontal, as they are throughout a large part of New York, there are sheets or strata of varying hardness, one upon another. Denudation trenches these, and streams carve valleys along their lines of flow, while rainwash and weathering more slowly wear away the interstream areas.

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* Dodge, Proc. Boston Soc. Nat. Hist., Vol. XXVI, 1895, pp. 257–273.

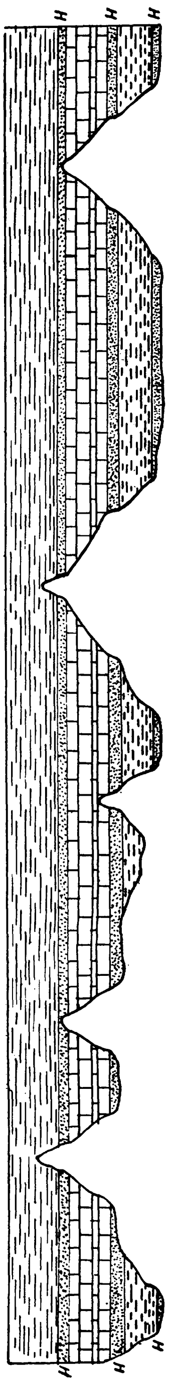

FIG. 14.—STAGE OF YOUTH OR EARLY MATURITY IN A HIGH PLAIN OR PLATEAU WITH STRATA OF VARIABLE HARDNESS (STRATA MARKED H, HARD) AND, TYPICALLY, IN AN ARID CLIMATE. CONTRAST WITH STAGE B OF FIGURE 2.

Such a region, starting perhaps as a plain, is then much dissected, so that, looked at in detail, it has little resemblance to a true plain, but is a very hilly land, especially if its elevation above the sea is great.

However, the fact that the rocks are in horizontal sheets, which are variable in their power of resistance to denudation, will make it necessary that the hill tops shall reach to a nearly uniform level. This is because, when an unusually *hard layer* is reached by the agents of denudation, further cutting is resisted so much more decidedly than in the softer strata, that the further down-cutting is held back at the level occupied by this hard horizontal bed. Hence, even if the original surface reached to different levels, the softer rocks are removed with some ease and the harder ones less easily, so that, while further lowering is slow in the case of those places that are capped by a hard layer, others that are higher, but are capped by softer rocks, will wear down more rapidly, soon reaching the level of the hard layer by which the denudation is being delayed.

In eastern New York there are plains of this origin, though they occupy rather small areas. It is this fact also which accounts for the table-lands and mesas of the plateau region of the West.* These level-topped areas, perhaps deeply dissected by cañons, stand up at a uniform level because of the protection offered by the hard layers (Figs. 16 and 17). The plains of several levels in Texas exist in horizontal rocks †; and the plains and plateaux of central and western New York also owe their present form to this condition.

The plateau of central, southern and western New York is a very hilly country, but the hills reach to a fairly uniform elevation,

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* Powell Exploration, Colorado River, 1875, 1–214; Dutton, Monograph U. S. Geol. Survey, Vol. II, 1882.

† Hill, Am. Geol., Vol. V, 1890, 9–29.

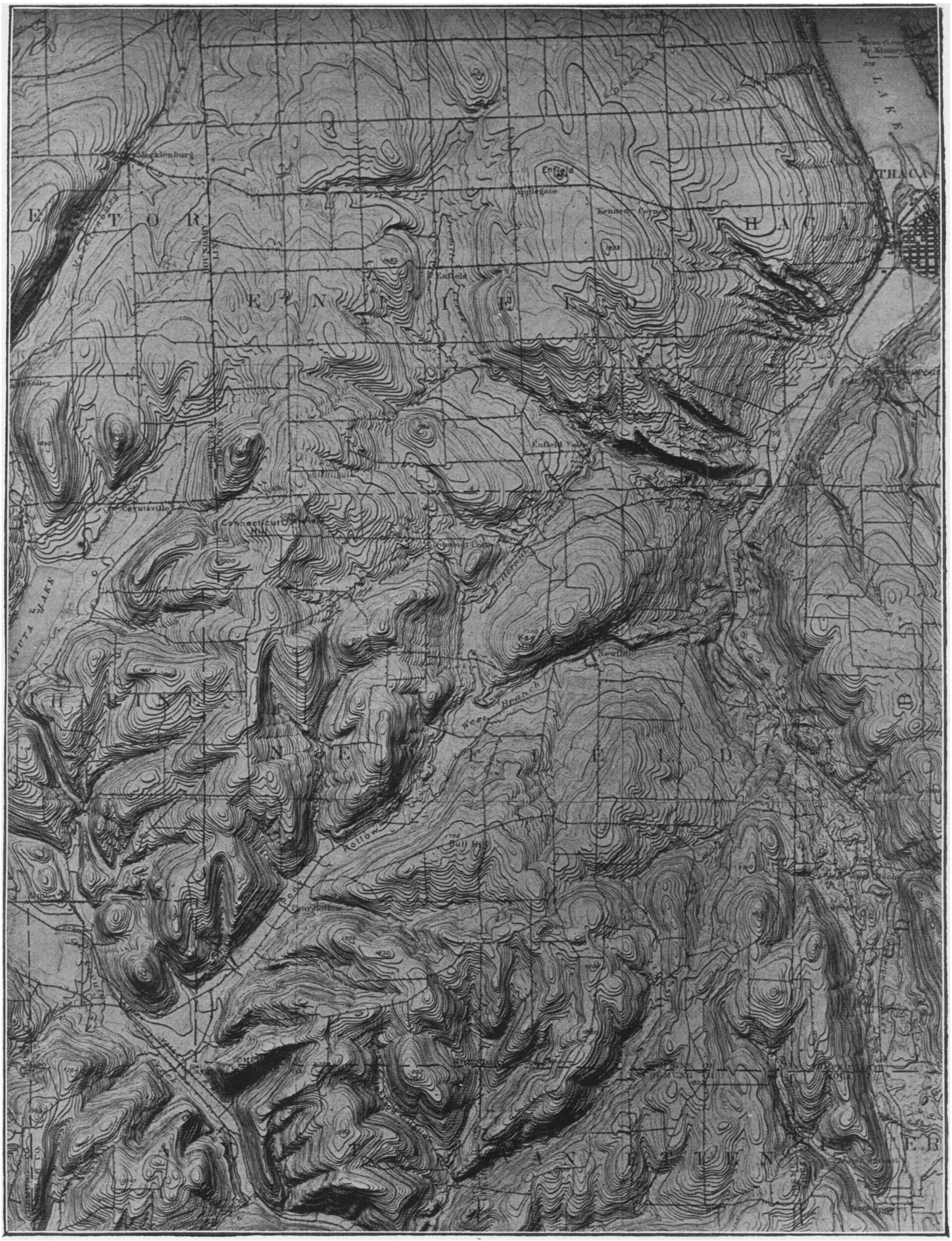

FIG. 15.—PHOTOGRAPH OF A MODEL OF THE DISSECTED PLATEAU OF WESTERN CENTRAL NEW YORK, NEAR ITHACA. (MODEL OF ITHACA SHEET (U. S. GEOL. SURVEY) BY WM. STRANAHAN).

and many of them are nearly level-topped, so that, standing upon the crests of the higher hills, one looks across to other crests of nearly the same elevation. This is because the Upper Devonian strata are coarse and sandy shales which resist the agents of denudation. In western New York, in Chautauqua County, there are two plains, (1) that IN which Lake Erie is placed, which is faced on the southern side by a steep escarpment,* rising (2) to a hilly plateau region IN which Lake Chautauqua is situated. At present there seems to be no definite reason in the rock structure for this upland plateau and for the escarpment separating it from the lower plain; but in southern Chautauqua County, and across the line, in Pennsylvania, there are remnants of a conglomerate bed, now remaining upon the surface in the form of "rock cities", † where the great blocks, loosened by weathering, and perhaps somewhat disturbed by post-glacial action, now stand in confused, and often fantastic arrangement upon the surface of the land (Fig. 18).

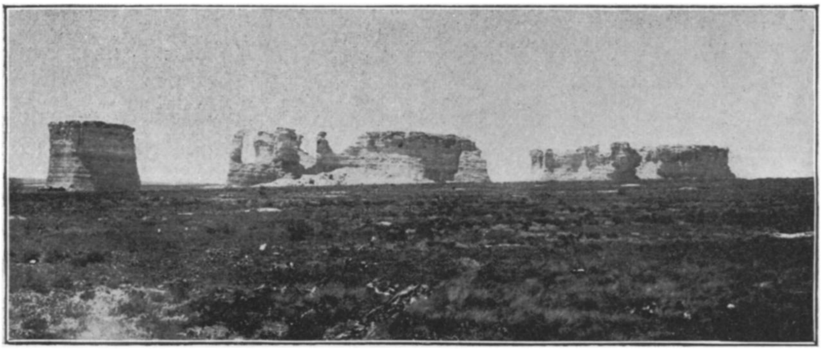

FIG. 16.—BUTTES ON THE PLAINS OF WESTERN KANSAS, REMNANTS OF A HIGHER LEVEL LEFT STANDING BY DENUDATION (PHOTOGRAPH BY PROF. WILLISTON).

It has seemed to me probable that the western plateau (and perhaps also that of southern-central New York), together with its north-facing escarpment, might have originated as the result of the former protection of this conglomerate stratum, most of which is now removed, the last remnants having been carried away by the ice. To test this I requested Mr. Bonsteel, Assistant in Geology at Cornell, to look about in Chautauqua County for remnants of this conglomerate to the north of the present "rock cities," and he has found fragments *in the till* in the neighborhood of Lake Chautauqua, and has gathered facts concerning the distribution of these fragments elsewhere. Therefore, either the ice has *moved northwards* in this region—not a very probable alternative—or when the glacier came upon this region some remnants of this conglomerate stratum were still left on the surface. If this latter explanation is correct, as seems probable, the plateau character and the escarpment of this section are explained.

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* Tarr, Bull. 109, Cornell Univ. Agri. Experiment Station, 1896, p. 92.

† Hall, Geol. of New York, 4th Dist., 1843, 284–285; Carll, Second Geol. Survey, Pennsylvania, Report III, 1880, pp. 57–79; Same, Report IIII, 1883, pp. 195–208.

At the base of the Lake Erie escarpment, on the northern border of the plateau just described, there is another plain, of which the bottom of Lake Erie forms a part. In New York a narrow portion of this plain extends between the escarpment and the shores of Lake Erie. Upon this the City of Buffalo is situated; and in this region it is a broad, quite level plain, disappearing gradually under the lake toward the west, and losing its character toward the south as it ascends toward the high plateau of southwestern New York. It extends eastward, gradually losing its typical character as a plain, and toward the north it ends abruptly in the escarpment (Fig. 19) at Lewiston, Lockport, etc. This escarpment is determined by the presence of the hard Niagara limestone, which is also the cause for the Falls; and the plain itself, in its most typical portion, owes its levelness to the presence of this and other hard layers of nearly horizontal rocks.

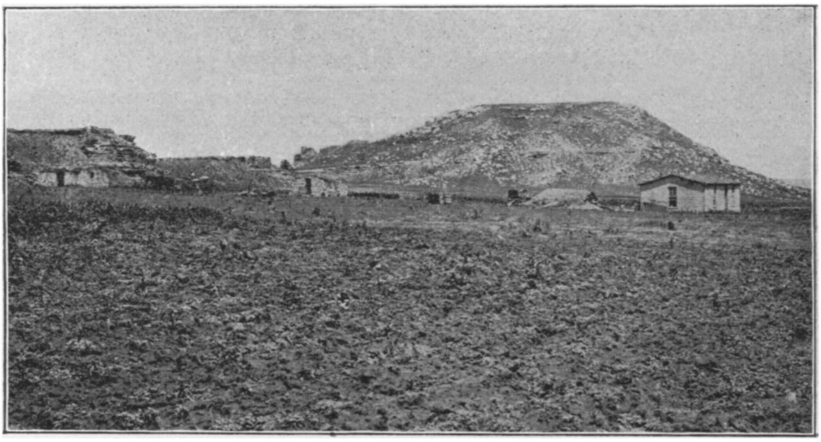

FIG. 17.—TO ILLUSTRATE THE PROCESS OF DESTRUCTION OF A PLAIN IN WESTERN KANSAS. HILLS CAPPED BY A HARD LAYER, BEING SEPARATED TO FORM BUTTES LIKE THOSE IN FIG. 16 (PHOTOGRAPH BY PROF. WILLISTON).

Below it, at the base of the north-facing Niagara escarpment, is another plain (Fig. 19) which itself is terminated by a north-facing bluff under the waters of Lake Ontario, the position of this being determined by the presence of the horizontal beds of the very durable Medina sandstone. This is one of the largest and most perfect plains in the State. From Lewiston to Irondiquoit Bay, and from the lake shore to the Niagara escarpment, which loses prominence toward the east, there is a wonderfully level plain crossed by the Rome, Watertown and Ogdensburg railway.

The *general* levelness of this plain is due to the rock structure; but there is a peculiar fact about it, the real explanation of which is not certain. The Niagara and Lake Erie escarpments are trenched by *deep* valleys of pre-glacial origin, the positions of which are now plainly apparent in the topography; and the two plains which these escarpments bound are also dissected; but the Ontario plain is not furrowed by such valleys. In its deepest point the bottom of Lake Ontario is about 738 feet below the lake level, and hence somewhat more than this below the level of the Ontario plain.

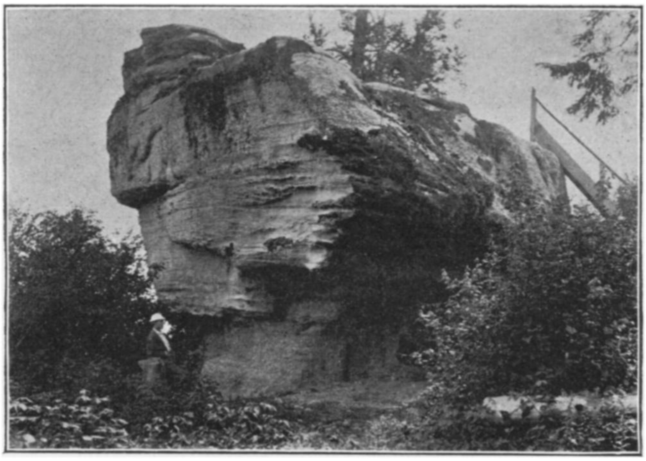

FIG. 18.—CONGLOMERATE BOULDER—A PART OF THE "ROCK CITIES."

There are two prominent theories to account for the basin of Lake Ontario, one that the continental glacier carved it out of the rock, the other that it was a pre-glacial river valley changed to a lake by various causes without marked ice erosion, and chiefly by drift dams left by the ice. If the latter is true, and the bottom of Lake Ontario is an old river valley at approximately the same level which it had before the Glacial Period, the Ontario plain during this time must have been crossed by good-sized valleys of streams entering this ancient and very deep valley. Since they are now invisible, it must be supposed that the glacial drift has obscured the pre-glacial irregularities, and that the plain is therefore only in part due to destructional origin, and in considerable part a plain of construction as the result of drift deposit (p. 42).

The alternative is, that the old surface to the north of the plain, on the site of the present lake, was a pre-glacial valley, whose bottom was not much lower than the present lake level, having since been reduced to the present level by some cause. There are three possible causes for its deepening,—ice erosion, faulting and folding. Of the two latter there is no proof whatsoever; but in favor of the former we have the fact that the *ice* has actually passed over this surface.* No attempt is made here to decide between these two theories, though it may be said that facts point more strongly toward ice erosion than toward the other explanation. Before a definite conclusion can be reached some detailed field work must be done along the margin of Lake Ontario.

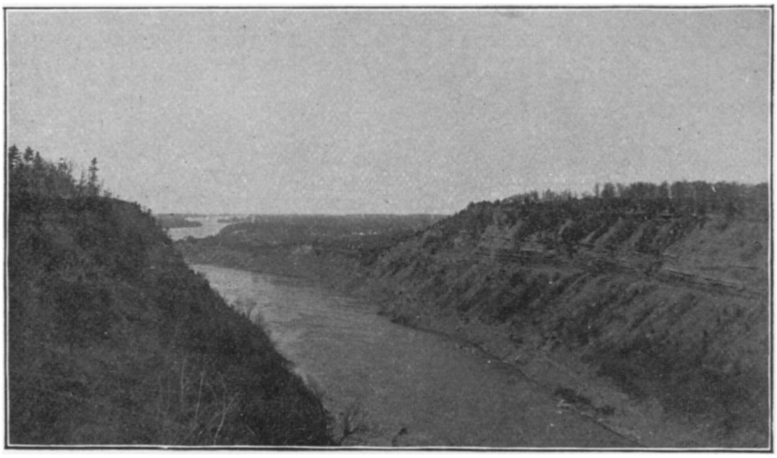

FIG. 19.—END OF NIAGARA GORGE SHOWING THE NIAGARA ESCARPMENT AND THE NORTHERN END OF THE UPPER PLAIN, WITH THE ONTARIO PLAIN STRETCHING NORTHWARD FROM THE BASE OF THE ESCARPMENT AND CROSSED BY THE NIAGARA RIVER BELOW THE GORGE (PHOTOGRAPH BY J. O. MARTIN).

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* It is to be noted that the greatest depth of Ontario is on the southern side of its eastern half, and that the glacier, coming against the Adirondack mountain mass, was turned to either side, the western arm going southwest toward this deepest point. Therefore at the place where, according to this theory, the greatest erosion took place, there must have been a decided increase in ice movement due to this concentration of the parts of the glacier which were prevented from going due southward because of the Adirondack obstruction.

*Peneplains.**—Standing on the top of the hills in the Highlands of New Jersey, or of Southern New England, it is found that though the rocks are folded and disturbed, some of the hill tops reach to a nearly uniform level, as they do in parts of Great Britain (p. 47). In England the explanation of this fact has been marine denudation, but in this country it is ascribed to denudation in the air, or subaerial denudation. If the land remained at a nearly uniform level for a long enough time, even the highest mountains would be planed down to nearly sea-level, or to *base-level.* In proof of this is the fact that New York City is situated in a hilly region which represents the last remnants of a once elevated mountain system, as do the hills of Connecticut, eastern Massachusetts and the Highlands of New Jersey.

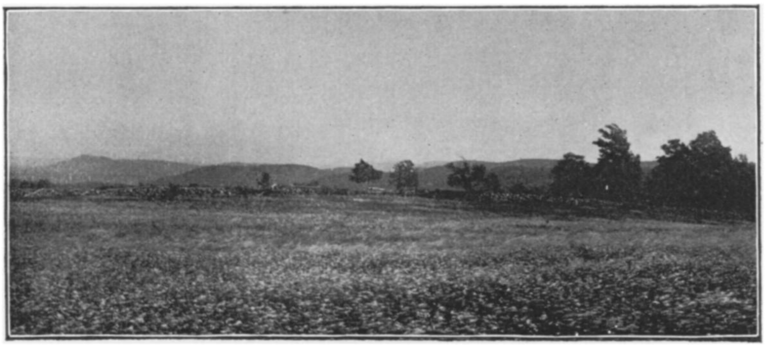

FIG. 20.—A VIEW ACROSS THE PENEPLAIN OF NEW ENGLAND (PHOTOGRAPH BY J. RITCHIE, JR.).

It is difficult to account for the uniformity of level of these hills on any other supposition than that at one time they were at a lower level with reference to the sea, having been either bevelled down to a hilly lowland condition or else to the condition of a plain, a *peneplain.*† The reason for this conclusion is as follows: It is known that the country was originally mountainous, because the rocks are very complexly folded; and these contorted strata vary in hardness. Therefore, at first tilted rocks of different kinds were raised to different heights. At present, in many cases, they stand, still at an elevation of 1,000 or 2,000 feet above the sea, but with the hilltops reaching to a rather uniform level, while between them there are valleys of no very great width. In all the time required to lower the surface so far, the result should have been the production of valleys with great width, and hence with mature form, while between them should rise hills of different elevations. To have brought nearly all of the peaks down to a nearly uniform level, the general elevation must have been reduced even lower than now; and the fact that the stream valleys at present are *not* broad or mature, shows that there has been a rather recent uplift.

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* Davis, Am. Journ. Sci., vol. xxxvii., 1889, p. 430; Davis and Wood, Proc. Boston Soc. Nat. Hist., 1888–1889, vol. xxiv., pp. 365–423; Davis, Bull. Geol. Soc. America, vol. ii., 1891, p. 545; National Geog. Mag., vol. v., 1893, p. 68; Bull. Geol. Soc. America, vol. vii., 1896, p. 377; Nat. Geog. Monograph, vol. i, 1896, p. 269.

† This may have been done by marine denudation or by subaerial denudation. For a critical discussion of this, with numerous references to the literature, see Davis, National Geog. Monog. Vol. I, 1896, p. 269.

Therefore the peneplain theory is, that the mountains were bevelled to the condition of a lowland, nearly to that of a plain, during the time when the land elevation had remained quiet for long periods. The surface was then uplifted, the streams began to cut deep valleys, and the old plain to be dissected, so that now only a few remnants remain in the hilltops, which tell of a former plain by the fact that they are of nearly the same elevation. During this time of ancient base-levelling, New York was also subjected to reduction, the Adirondacks and other mountains being lowered, and the New York-Pennsylvania plateau being reduced to a plain standing nearly at sea-level. An elevation ended this period of base-levelling, and again the streams had a steep slope. Since then they have cut their valleys so deeply into the surface of the plain, and weathering has broadened them so much, that the ancient peneplain is nearly destroyed, so that, so far as New York is concerned, there is no evidence left of this former peneplain condition, though the evidence of former reduction is found in the States immediately bordering this one.

I have attempted to state this theory fairly because it is a theoretical possibility. No peneplains of large size at present exist, and there is some reason for doubting if any ever have. This is not the place for a discussion of this subject.